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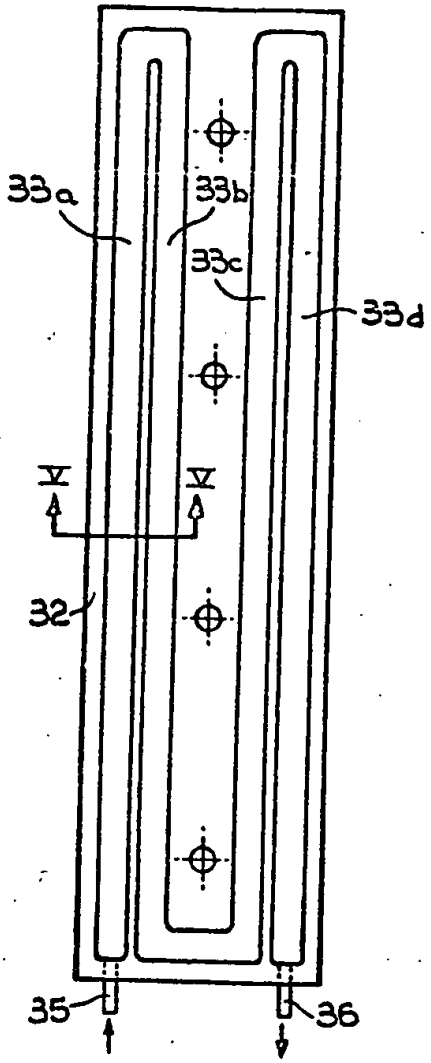


Fig. 4.

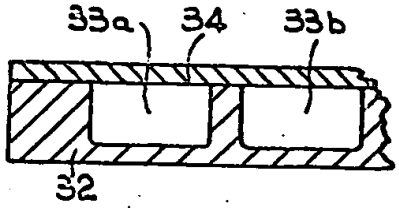


Fig. 5

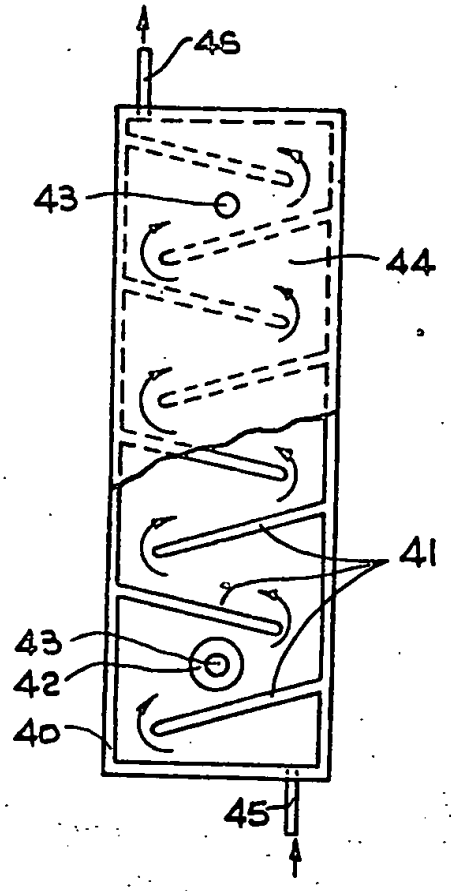


Fig. 6.

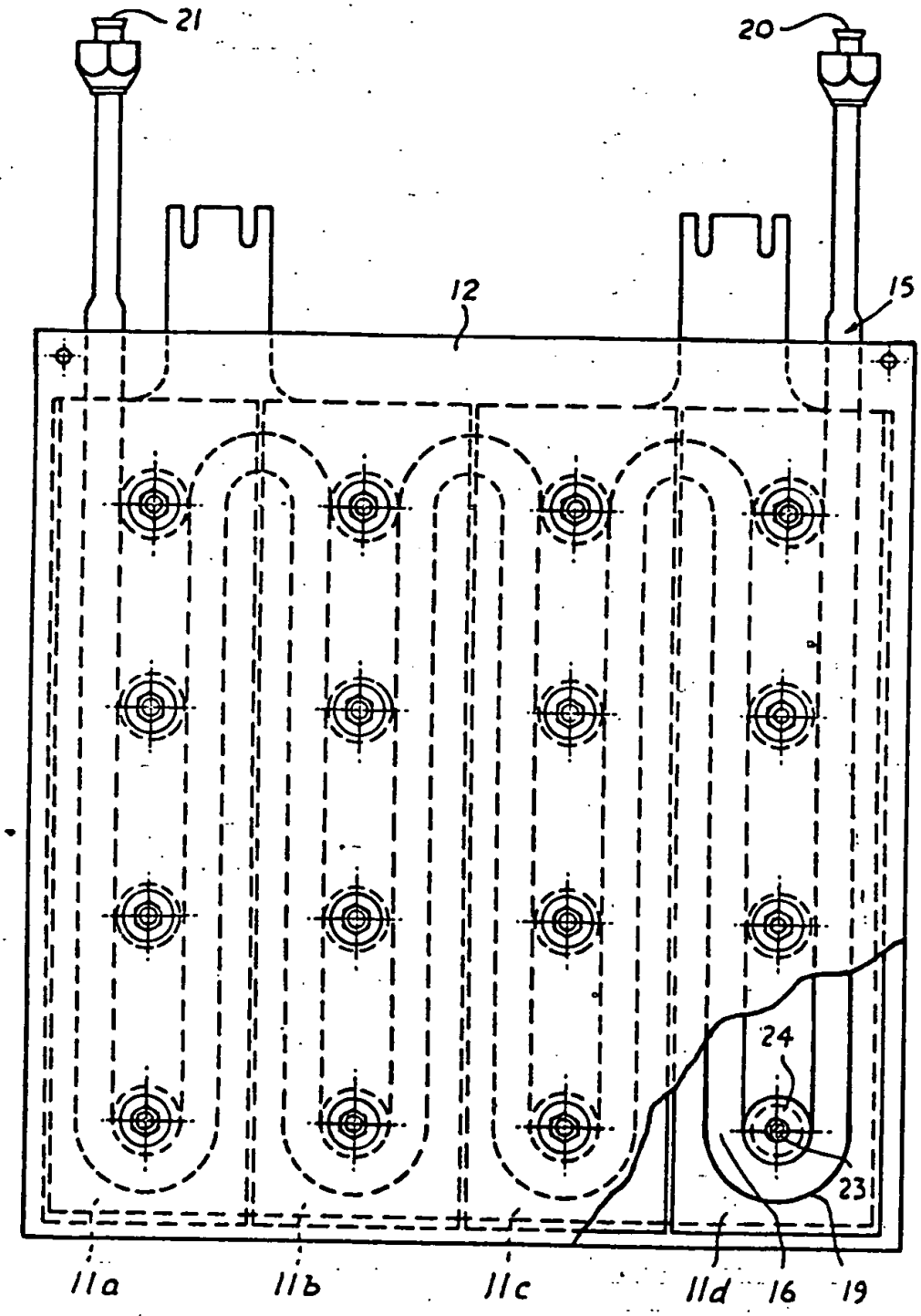


Fig. 1.

Fig 2.

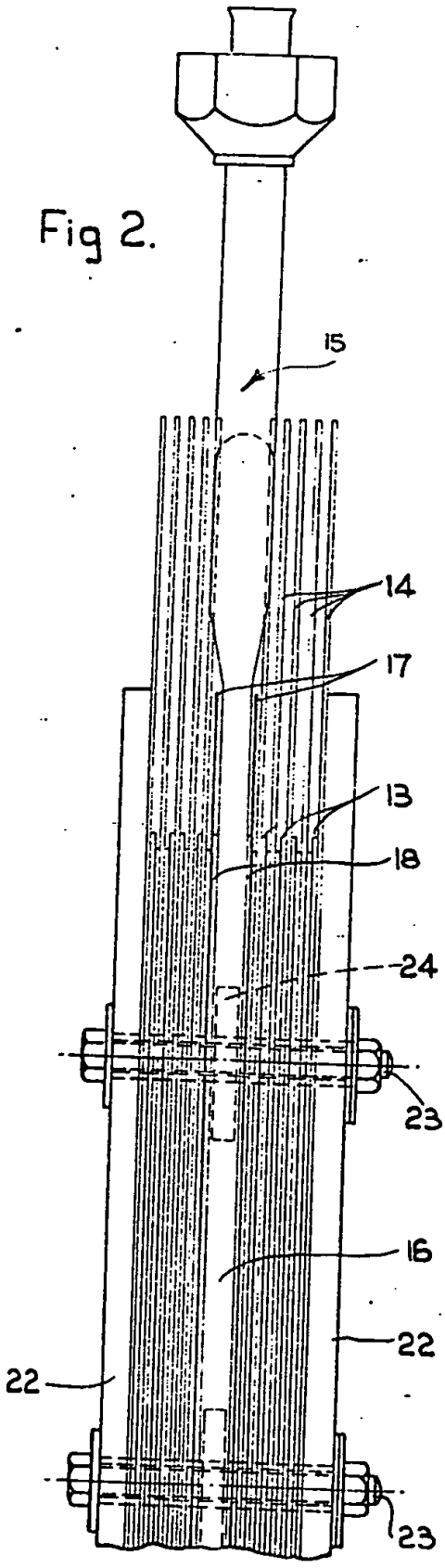
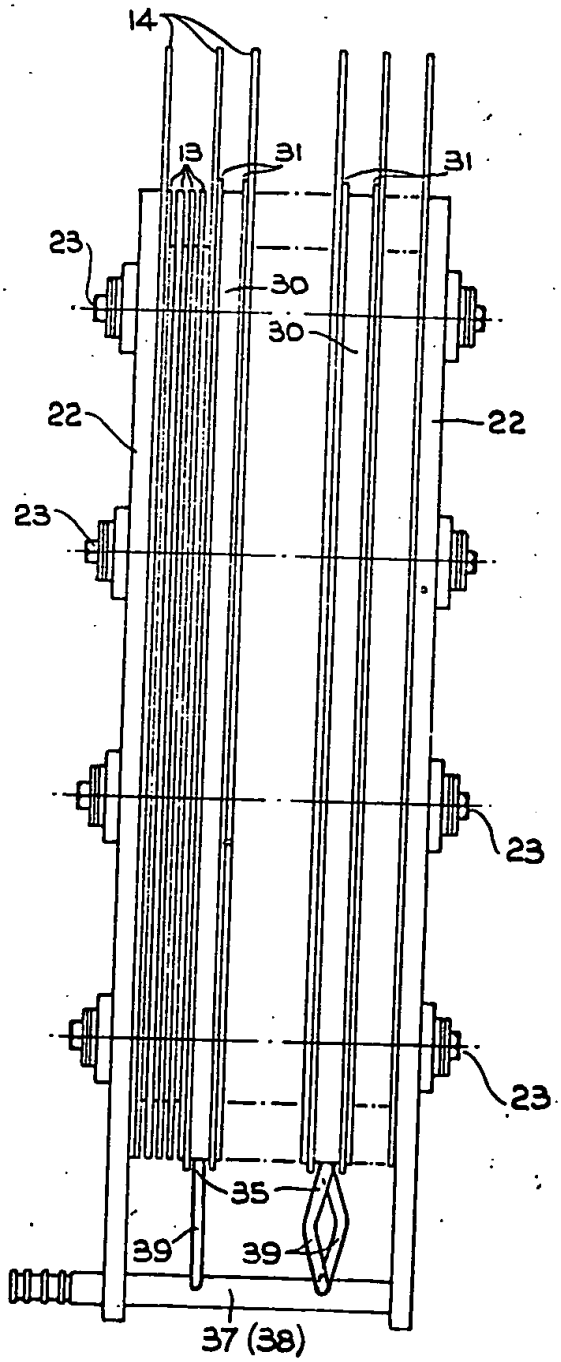


Fig. 3.



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Cooling of Dry Surface Contact Alternating Electric Current Rectifier Assemblies

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3 Claims

This invention relates to the cooling of dry surface contact rectifier assemblies of the kind comprising a plurality of so-called rectifier elements clamped together with interleaved connectors to form a stack or column.

The current carrying capacity of such assemblies is limited largely by the heat engendered by the passing of that current and attempts have been made in the past to improve the cooling by immersing the assemblies in oil, by passing cooling air over the elements, which have to be spaced apart accordingly, and by the provision of cooling fins interleaved with the elements beyond the periphery of which they extend to be cooled by the atmosphere or by forced draught.

None of these methods has proved to be very efficient and, especially with oil immersed assemblies, result in the taking up of a large amount of space. It is accordingly an object of this invention to provide a rectifier assembly of the kind described having cooling arrangements which are comparatively compact and which are of greater efficiency than those referred to above.

In a dry contact rectifier assembly composed of a number of stacked plate-like elements which are adapted to be cooled by the passing of a liquid coolant, such as water, along a tortuous path between adjacent elements at one or more selected points in the stack, the invention provides the combination at each such selected point of a pair of metal plates of which the opposing faces are maintained in good thermal conducting relationship respectively with flat parallel faces of a metal coolant conducting tube which is interposed between the plates and is bent back upon itself at least once within the outline of the adjacent parts of the stack, these adjacent parts being insulated electrically from the tube by thin electrically insulating material. Electric insulation in the form of a thin layer of a material having the requisite properties may be applied by spraying or may take the form of thin sheets of such material.

Where a combination as set forth above is provided at each of several selected points in the stack the supply of coolant thereto may be either in series or in parallel, preferably the latter in order to obtain an even cooling throughout the stack and a better method to obtain this result is to connect them so that whilst they are in parallel, the flow in one conduit is in the opposite direction to that in the next.

The invention will be further described by way of example with reference to certain embodiments thereof, three such embodiments being illustrated in the accompanying drawings, in which

Figure 1 is a front elevation, partly sectioned, of a complete rectifier assembly including cooler units,

Figure 2 is a side view to a larger scale of an upper portion of one of the stacks seen in Figure 1,

Figure 3 is a side elevation of a different form of rectifier assembly including cooler units of modified cross construction,

Figure 4 is a front elevation of one of the cooler units of Figure 3 with a lid thereof removed to show the path described by the conduit,

Figure 5 is a part section of the cooler unit taken on the line V—V of Figure 4 with the lid affixed thereto, and

Figure 6 is a view of yet another form of cooler unit, part of a lid thereof being broken away to reveal the interior.

The complete assembly illustrated in Figures 1 and 2 is composed of four separate stacks 11a, 11b, 11c, 11d placed side by side in a container 12, each of the stacks being made up in well known manner of rectifier elements in the form of rectangular metal plates 13 coated with semi-conductive and counter-electrode layers with connectors 14 interleaved as required between the elements.

A cooler unit, indicated generally 15, is interleaved with the components of each stack at a point midway along its length so that equal numbers of rectifier elements are disposed to either side of the cooler unit, thereby ensuring that both ends of the stack are cooled to the same extent. The cooler unit 15 consists of a length of metal tube 16, preferably of drawn copper, which has been deformed from its original circular shape by flattening to present flat parallel surfaces. These surfaces provide a good thermal contact of the tube 16 with flat metal plates 17 between which the tube is sandwiched, the plates 17 being insulated electrically from the aforesaid surfaces this sheets or layers 18 of electrically insulating material of good thermal conductivity. To increase further the area of contact between the tube 16 and the plates 17, the tube is turned back upon itself at 19 so as to execute two runs within the boundaries of the plates 17. In the complete assembly of Figures 1 and 2, the cooler units of the juxtaposed stacks are interconnected serially and for this purpose the tube 16 is continuous from the inlet 20 to the outlet 21 and is formed in serpentine fashion with a succession of reverse bends, the bends being made about such a radius that two runs of tube lie within each of the stacks.

The efficiency of any system of conduction cooling of rectifier assemblies of the kind described is very largely dependent upon the intimacy of contact which is obtained between the rectifier elements and/or connectors and the member used to conduct the heat away from them, and small pockets of air remaining between the abutting surfaces have a marked deleterious effect upon that efficiency. It is therefore desirable that the surfaces of the cooler units should be substantially flat and parallel, that the contacting surfaces of the connectors should be of substantially the same surface dimensions as the rectifier elements, and that the assembly should be clamped up tightly.

To an achievement of the last-mentioned requirement, each of the stacks is held between rigid end plates 22, preferably stout boards of the material sold under the Registered Trade Mark "Bakelit", which are clamped together by bolts 23 passing through insulating bushes in the stack at several equispaced points to ensure uniformity of clamping pressures. Spacers in the form of bobbins

24 through which the bolts 23 pass are fitted between the runs of the tube 16 and serve to locate the tube as well as to prevent it being crushed under the clamping pressure.

Coolant, usually water in view of its general availability, is supplied to the inlet 20 and in passing through the tube 16 to the outlet 21 extracts heat generated in the rectifier. The flow of coolant is so adjusted that the rise in temperature of the coolant in passing through the tube 16 is not so great as to impair seriously the cooling efficiency of cooler units, or portions thereof, approaching the outlet.

The rectifier assembly shown in Figure 3 is composed of a single stack of rectifier elements 13 with interleaved connectors 14, the stack being held between rigid end plates 22 clamped together by bolts 23 in the manner previously described with reference to Figures 1 and 2. There are, however, two cooler units interleaved with the components of the stack. These units, indicated 30, are disposed symmetrically in relation to the length of the stack in such manner that between either one of the cooler units and the adjacent end plates there are half as many rectifier elements as there are between the two cooler units, thereby ensuring that heat may be conducted from any one of the elements to one of the cooler units without having to pass through more than a certain number of other elements, this member being determined in accordance with the permissable degree of heating of the elements. The cooler units 30 have thin layers or sheets 31 of electrically insulating material on each side to separate them electrically from the stack, the layers or sheets being of good thermal conductivity.

Referring particularly to Figures 4 and 5, the cooler units 30 are each in the form of a block 32, of such material as brass or die cast aluminum, having substantially the same peripheral configuration as the rectifier elements 14 but greater thickness. In one of the faces of this block several straight grooves 33a . . . . 33d are machined to extend parallel with the longer sides of the block, these grooves being of rectangular section as seen in Figure 5. The grooves are interconnected adjacent the shorter sides of the block so that when the above-mentioned face of the block is covered they form a conduit describing a long path in relation to the area of the block. The face is covered by a flat lid 34 which is soldered or bonded to the block in a manner appropriate to the materials of which the block and lid are made. Hollow spigots are in communication at 35 and 36 with the ends of the conduit formed by the grooves to act as an inlet and an outlet for the flow of coolant through the cooler unit. As seen in Figure 4 the inlet and outlet are both located on the same side of the block but with an alternative arrangement of the grooves they may be dispersed to lie on different sides.

The end plates 22 are extended downwards beyond the periphery of the stack to provide support for two header pipes 37 and 38 (the former obscuring the latter in Figure 3) which extend parallel to the length of the stack. Connection of the hollow spigots at 35 and 36 with the headers 37, 38 is made through flexible pipes 39 so that the two cooler units are connected in parallel to the supply of coolant, it being preferred that in the case of one of the units the spigot at 35 is connected to the header 37 and that at 36 to the header 38 whilst in the case of the other unit the connections are crossed to connect the spigot at 35 with the header 38 and that at 36 with the header 37; in this way the flow of coolant through the conduits of the cooler units will be in opposite directions and so tend to reduce temperature gradients in the planes of the elements in the stack. In operation, coolant, usually water, is supplied to one of the headers, the other header there acting as a return pipe.

It will be appreciated that the embodiment of the cooler unit in the form of a block with a lid fixed thereto considerably facilitates making flat and truly parallel those surfaces thereof which come into contact with adjacent components of the stack. As previously explained, it is highly desirable that these surfaces be flat and parallel in order to eliminate air pockets between themselves and the adjacent components of the stack.

Elimination of the above mentioned air pockets to a still greater extent may be obtained by the application of a suitable compound to the surfaces of the cooler units, the majority being squeezed out under the clamping pressure and the remainder filling the pockets in which air would otherwise be trapped. The compound used for this purpose should evidently be of a better thermal conductivity than the air which it replaces.

The compact, tightly clamped assembly lends itself particularly favourably to protection from deleterious atmospheric effects by encapsulation in a suitable plastic compound, whilst when it is to be called upon to operate in hot surroundings such an assembly may be mounted within a thermally insulating box in order to prevent it absorbing heat from those surroundings.

The form of cooler unit shown in Figure 6 has a base 40 which is diecast from aluminum in the shape of an open-tapped box having internal walls 41 to act as baffles. Bosses 42 formed in the base define holes 43 through which pass the bolts used to clamp the stack together. A metal lid 44 is affixed to the base to cover the open top thereof, the unit then being in the form of a closed flat box having flat parallel faces. Inlet and outlet pipes 45 and 46 communicate with the interior of the box at opposite ends thereof. The baffles 43 are so arranged that the flow of coolant through the interior of the box is constrained to follow a tortuous path thereby ensuring that the coolant is well distributed. The baffles also serve to reinforce the box against collapse under the clamping pressure.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a dry contact rectifier assembly composed of a number of stacked plate-like elements which are adapted to be cooled by the passing of a liquid coolant, such as water, along a tortuous path between adjacent elements at one or more selected points in the stack, the combination at each such selected point of a pair of metal plates of which the opposing faces are maintained in good thermal conducting relationship respectively with flat parallel faces of a metal coolant conducting tube which is interposed between the plates and is bent back upon itself at least once within the outline of the adjacent parts of the stack, these adjacent parts being insulated electrically from the tube by thin electrically insulating material.

2. The combination according to claim 1, in which the electrically insulating material is in the form of sheet interposed between the plates and the adjacent parts of the stack, the tube being in direct contact over the full extent of its parallel faces with the pair of plates.

3. The combination according to claim 1, or 2 in which the tube is of drawn copper which has been deformed from its original circular shape by flattening.

The Queen's Printer and Controller of Stationery, Ottawa, 1959

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